

The Claims Defining the Invention are as Follows

1. A detector device for detecting incident radiation at particular wavelengths, comprising:-

a base layer of material;

5 a cavity formed on said base layer, the cavity having a pair of reflectors, one being a first reflector layer disposed in fixed relationship with respect to the base layer and the other being a second reflector layer disposed in opposed spaced relationship to the first reflector layer to form a resonant cavity between the layers, the reflectors being disposed a cavity length from each
10 other; and

a detector disposed within the cavity to absorb incident radiation therein for detection purposes.
2. A detector device as claimed in claim 1, wherein the first reflector layer and the second reflector layer are disposed in substantially parallel spaced
15 relationship to each other.
3. A detector device as claimed in claim 1, wherein the second reflector layer is formed so that at least a portion of it is of slightly concave form with respect to the interior of the cavity.
4. A detector device as claimed in any one of the preceding claims, wherein the
20 surface of the detector for receiving incident radiation is provided with an anti-reflection (AR) coating to prevent Fresnel reflections therefrom that may otherwise form a complicated coupled multi-cavity structure.
5. A detector device as claimed in any one of claims 1 to 3, wherein the detector is formed as an integral part of the reflector structure.

6. A detector device as claimed in any one of the preceding claims, wherein the base layer comprises an integrated circuit.
7. A detector device as claimed in any one of the preceding claims, wherein the base layer is a substrate.
- 5 8. A detector device as claimed in claim 7, wherein the substrate material is a semiconductor or semiconductor system that is transparent to radiation in the wavelengths to be detected by the detector device.
9. A detector device as claimed in any one of the preceding claims, wherein the cavity length corresponds to optical wavelengths in the infrared region.
- 10 10. A detector device as claimed in any one of the preceding claims, wherein the detector is an active detector layer disposed in juxtaposition with the first reflector layer.
11. A detector device as claimed in any one of the preceding claims, wherein the second reflector layer is formed on a moveable membrane disposed in spaced
15 relationship to said base layer and suspended relative thereto at the periphery of the membrane by a support structure.
12. A detector device as claimed in claim 11, including a pair of electrodes to control the movement of said membrane.
13. A detector device as claimed in claim 12, wherein the electrodes are
20 constituted by the reflectors.
14. A detector device as claimed in claim 12, wherein the electrodes are juxtaposed with the reflectors, one electrode with the one reflector and the other electrode with the other reflector.
15. A detector device as claimed in any one of claims 11 to 14, wherein the first
25 reflector layer and the detector are integrated or integral with the base layer.

16. A detector device as claimed in claim 15, wherein said support structure is mounted upon a further base layer disposed in opposing, spaced relationship to the detector by support means.
17. A detector device as claimed in claim 16, wherein the further base layer
5 comprises a readout integrated circuit.
18. A detector device as claimed in claim 17, wherein the support means comprises indium bumps that form part of the connection between the readout integrated circuit of the device and the detector.
19. A detector device as claimed in claim 15, wherein said support structure is
10 mounted upon the detector or the base layer of the device.
20. A detector device as claimed in claim 19, wherein the first reflector layer is disposed on the surface of the base layer and is embedded between the detector and the base layer.
21. A detector device as claimed in 19, wherein the detector together with the first
15 reflector layer is embedded within the substrate on one side thereof so that the detector is exposed on one side of the substrate and the first reflector layer is disposed within the substrate to be integral therewith, and the other side of the substrate having a window therein down to the detector and the first reflector layer to reveal the first reflector layer from the other side of the
20 substrate to enable the passage of radiation therethrough.
22. A detector device as claimed in claim 19, wherein the first reflector layer is preferred to be disposed on another detector having a different wavelength sensitivity to incident radiation than the first detector, so that the first reflector layer is interposed between the two detectors, and the other detector is
25 disposed on the base layer.

23. A detector device as claimed in claim 22, wherein the other detector is of a shorter wavelength sensitivity to incident radiation to be detected than the first detector, and the base layer is a substrate.
24. A detector device as claimed in claim 22, including another reflector layer
5 juxtaposed with the base layer, and interposed between the other detector and the base layer, to define another cavity between the second reflector layer and the other reflector layer, said cavities being conjunctively tunable by moving the membrane of the second reflector layer.
25. A detector device as claimed in claim 24, wherein the other detector is of a
10 longer wavelength sensitivity to incident radiation to be detected than the first detector.
26. A detector device as claimed in any one of claims 11 to 14, wherein the first reflector layer and the detector are preferably discrete from the base layer, whereby the second reflector layer and the moveable membrane are
15 interposed between the detector and the base layer.
27. A detector device as claimed in claim 28, wherein the detector forms part of a homogeneous layer of material having the first reflector juxtaposed on one side thereof, distal from the base layer, and the second reflector juxtaposed on the other side thereof, proximal to the base layer, whereby a recess is
20 formed within the homogeneous layer of material adjacent to the second reflector layer to form an air gap within the cavity, and the detector is defined by the residual homogeneous layer of material disposed between the recess and the first reflector layer.
28. A detector device as claimed in any one of claims 11 to 27, wherein the
25 membrane and one reflector is shaped in accordance with a prescribed membrane geometry.
29. A detector device as claimed in any one of claims 11 to 28, wherein the displacement of the suspended moveable membrane can be up to the full

length of the air gap provided in the cavity, but is adjusted to avoid the membrane contacting the reflector, detector or the readout integrated circuit, depending upon the particular detector arrangement.

5 30. A detector device as claimed in any one of claims 11 to 29, wherein the membrane is formed of silicon nitride.

31. A detector device as claimed in any one of claims 11 to 30, wherein the support structures are formed of zinc sulphide.

32. A detector device as claimed in any one of the preceding claims, wherein the base layer is formed from an infrared sensitive material.

10 33. A detector device as claimed in claim 32, wherein the infrared sensitive material is mercury cadmium telluride (MCT).

34. A method for fabricating a detector device for detecting incident radiation at particular wavelengths, the method including:-

providing a base layer of material;

15 forming one reflector in fixed relationship with respect to the base layer;

forming another reflector in opposed spaced relation to the one reflector so as to form a resonant cavity between the pair of reflectors, the reflectors being disposed a cavity length from each other; and

20 forming a detector to be disposed within the cavity for absorbing incident radiation therein for detection purposes.

35. A method as claimed in claim 34, including disposing the one reflector and the other reflector in substantially parallel spaced relationship to each other.

36. A method as claimed in claim 34, including forming the other reflector so that at least a portion of it is of slightly concave form with respect to the interior of the cavity.
- 5 37. A method as claimed in any one of claims 34 to 36, including coating the surface of the detector that receives incident radiation with an anti-reflection (AR) coating to prevent Fresnel reflections therefrom that may otherwise form a complicated coupled multi-cavity structure.
38. A method as claimed in any one of claims 34 to 36, including forming the detector as an integral part of the reflector structure.
- 10 39. A method as claimed in any one of claims 34 to 38, wherein the base layer comprises an integrated circuit.
40. A method as claimed in any one of claims 34 to 38, wherein the base layer is a substrate.
- 15 41. A method as claimed in claim 40, wherein the substrate material is a semiconductor or semiconductor system that is transparent to radiation in the wavelengths to be detected by the detector device.
42. A method as claimed in any one of claims 34 to 41, wherein the cavity length corresponds to optical wavelengths in the infrared region.
43. A method as claimed in any one of claims 34 to 42, including:
- 20 forming a moveable membrane;
- suspending the membrane at the periphery thereof with a support structure so that it is disposed in spaced relationship to the base layer;
- forming the other reflector on the moveable membrane; and
- providing a pair of electrodes to control the movement of the membrane.

44. A method as claimed in claim 43, wherein the electrodes are constituted by the reflectors.

45. A method as claimed in claim 43, wherein the electrodes are juxtaposed with the reflectors, one electrode with the one reflector and the other electrode with
5 the other reflector.

46. A method as claimed in any one of claims 34 to 45, including forming the one reflector and the detector so that they are integrated or integral with the base layer.

47. A method as claimed in claim 46, including:

10 growing a first reflector layer on the base layer to form the one reflector of the cavity resonator;

growing an active detector layer on the one reflector to form one side of the detector device;

15 forming a second reflector layer on a further base layer to form the other reflector of the cavity resonator and the other side of the detector device;

conjoining the sides of the detector device relative to each other so that the one reflector is disposed in confronting relationship with the other reflector and the reflectors are spaced apart, with the detector disposed therebetween; and

20 bonding the two sides together to form an integral detector device with the reflectors disposed in spaced apart relationship to each other to form the resonant cavity with the detector disposed therein.

48. A method as claimed in claim 47, including forming support means on one side or the other of the detector device to space the reflectors apart when
25 conjoining one side relative to the other.

49. A method as claimed in claim 47 or 48, wherein the further base layer comprises a readout integrated circuit.
50. A method as claimed in claim 48 or 49, including forming the support means from indium bumps.
- 5 51. A method as claimed in any one of claims 47 to 50, wherein the conjoining and bonding involve a flip-chip bonding process.
52. A method as claimed in any one of claims 47 to 51, including epitaxially growing the one reflector as a wide bandgap dielectric stack prior to growing the active detector layer or layers.
- 10 53. A method as claimed in claim 52, wherein the one reflector is an MCT/cadmium telluride (CdTe) $\lambda/4$ dielectric stack.
54. A method as claimed in any one of claims 47 to 53, including suspending the other reflector upon the further base layer.
55. A method as claimed in any one of claims 47 to 54, including forming the other
15 reflector on, or as, a moveable membrane disposed in opposing, spaced relationship to the further base layer and suspended relative thereto at the periphery of the membrane by a support structure.
56. A method as claimed in claim 46, including forming the membrane so that it is
20 suspended by a support structure mounted upon the detector or base layer of the device.
57. A method as claimed in claim 56, including growing a first reflector layer on the surface of the base layer to constitute the one reflector, and depositing the detector thereon so that the first reflector layer is embedded between the base layer and the detector.
- 25 58. A method as claimed in claim 56, including:

embedding the detector in one side of the base layer;

etching a window in the base layer from the other side thereof down to the detector to reveal the rear thereof;

5 depositing a first reflector layer on the rear of the detector to form the one reflector of the cavity resonator; and

forming a second reflector layer disposed in opposing relationship to the base layer to form the other reflector of the cavity resonator.

59. A method as claimed in claim 58, including suspending the other reflector upon the base layer.

10 60. A method as claimed in claim 56, including:

depositing another detector on the base layer;

growing a first reflector layer on the other detector to form the one reflector of the cavity resonator;

15 depositing the first detector on the first reflector layer and the other detector so that the first reflector layer is interposed between the two detectors; and

forming a second reflector layer in opposing, spaced relationship to the first detector to form the other reflector of the cavity resonator;

wherein the other detector has a different wavelength sensitivity to incident radiation than the first detector.

20 61. A method as claimed in claim 60, wherein the other detector is of a shorter wavelength sensitivity to incident radiation to be detected than the first detector, and the base layer is a substrate.

62. A method as claimed in claim 56, including:-

growing another reflector layer on the base layer to form a further reflector of a second resonator cavity within the device;

depositing a another detector on the other reflector layer so that the other reflector layer is interposed between the other detector and the base layer;

5 growing a first reflector layer on the other detector to form the one reflector of the first resonant cavity within the device;

depositing the first detector on the first reflector layer and the other detector so that the first reflector layer is interposed between the first detector and the other detector; and

10 forming a second reflector layer in opposing, spaced relationship to the first detector to form the other reflector of both cavity resonators;

wherein one cavity is defined between the first reflector layer and the second reflector layer, and another cavity is defined between the other reflector layer and the second reflector layer.

15 63. A method as claimed in claim 64, wherein the other detector is of a longer wavelength sensitivity to incident radiation to be detected than the first detector.

64. A method as claimed in any one of claims 34 to 45, including:

20 forming: (i) a first reflector layer upon one side of a layer of homogeneous material sensitive to the incident radiation at the wavelength(s) to be detected to form the one reflector of the resonant cavity; and (ii) the detector within the layer of homogeneous material with an air gap to expose the detector to the other side of the homogeneous material; the first reflector layer and the detector being formed discretely from the base layer
25 to constitute a first half of the device;

forming: (i) the moveable membrane; and (ii) a second reflector layer to form the other reflector of the resonant cavity thereon; on the base layer so that the second reflector layer, the moveable membrane and the base layer constitute a second half of the device discrete from the first half of the device; and

conjoining the first half and the second half of the device so that the second reflector layer is juxtaposed and bonded to the other side of the layer of homogeneous material;

whereby the second reflector layer and the moveable membrane surmounts the air gap and the detector to form the cavity with the detector disposed therein.

65. A method as claimed in claim 64, including:

growing the first reflector layer on one side of the layer of homogeneous material to be distal from the base layer in the end device;

etching the other side of the layer to form a recess that constitutes the air gap of the resultant cavity, the residual material disposed between the recess and the first reflector layer defining the detector; and

juxtaposing the second reflector layer on the other side of the layer of homogeneous material so that it is proximal to the base layer.

66. A method as claimed in any one of claims 34 to 65, including:

forming a sacrificial layer of a prescribed material on the base layer, the material having a high etch selectivity for releasing the membrane in a suspended and spaced relationship from the base layer, as appropriate;

forming the membrane on the sacrificial layer using a deposition technique characterised by providing the required intrinsic stress in the membrane;

depositing the second reflector layer on the membrane to form the other reflector;

patterning the further layer in accordance with a prescribed membrane geometry;

5 etching the second reflector layer to achieve said prescribed membrane geometry;

initially etching the sacrificial layer to remove regions thereof down to the base layer, as appropriate, exposed by said etching;

10 protecting those regions of the sacrificial layer intended to function as the residual support structure of the membrane; and

finally etching the remaining unprotected regions of the sacrificial layer and removing the protection from said support structures to suspend the membrane in spaced relation to the base layer.

15 67. A method as claimed in claim 66, wherein the membrane is formed of silicon nitride.

68. A method as claimed in claim 66 or 67, wherein the sacrificial layer is formed of zinc sulphide.

69. A method as claimed in any one of claims 66 to 68, wherein the base layer is a substrate formed from an infrared sensitive material.

20 70. A method as claimed in any one of claims 66 to 68, wherein the base layer is a readout substrate formed of silicon.

71. A method as claimed in any one of claims 66 to 70, wherein the deposition technique for forming the membrane is plasma enhanced chemical vapour deposition (PECVD).

72. A method as claimed in any one of claims 66 to 71, wherein the second reflector layer is etched using an anisotropic etching process.
73. A method as claimed in claim 72, wherein the anisotropic etching process for the second reflector layer involves dry etching.
- 5 74. A method as claimed in claim 73, wherein the dry etching involves plasma etching.
75. A method as claimed in claim 74, wherein the plasma etching is reactive ion etching.
76. A method as claimed in any one of claims 66 to 75, wherein the sacrificial
10 layer is initially etched using an anisotropic etching process.
77. A method as claimed in claim 76, wherein the anisotropic etching process for initially etching the sacrificial layer involves dry etching.
78. A method as claimed in any one of claims 66 to 77, wherein the protection of the support structures is provided by photoresist.
- 15 79. A method as claimed in any one of claims 66 to 78, wherein the remaining unprotected regions of the sacrificial layer are finally etched using an isotropic etching process.
80. A method as claimed in claim 79, wherein the isotropic etching process involves a final release wet etch that undercuts the remaining membrane.
- 20 81. A detector device for detecting incident radiation at particular wavelengths fabricated according to the method as claimed in any one of claims 34 to 80.
82. A detector device for detecting incident radiation at particular wavelengths substantially as herein described in any one of the embodiments, with reference to the accompanying drawings as appropriate.

83. A method for fabricating a detector device for detecting incident radiation at particular wavelengths substantially as herein described in any one of the embodiments, with reference to the accompanying drawings as appropriate.